MoHURD Eco-City Implementation Guideline for

Water Management

(Water Supply, Waste Water Treatment, Drainage and Storm Water Management)

Preamble. This Eco-City Implementation Guideline has been developed with the assistance of the Europe-Chine Eco-Cities Link Project (EC Link), and been submitted by the Chinese Society for Urban Studies (CSUS). It draws on the work done by the EC Link project in the development of sectoral toolboxes[1] which present European and Chinese best practices, urban development standards, indicators and methodologies for verification. Further, the development of this Guideline is informed by project work of MoHURD-affiliated pilot cities which are implementing eco-cities activities, and piloting innovative practices. EC Link has provided as inputs toolboxes for the following 9 sectors: compact urban development (CUD), clean energy (CE), green building (GB), green transport (GT), water management (water supply, waste water treatment and flood control) (WM), solid waste management (SWM), urban renewal and revitalization (URR), municipal finance (MF), and green industries (GI).

Objectives. The objectives of this Eco-City Implementation Guideline is to provide guidance, and to ensure compliance. The document is meant for all Chinese cities which are participating in the national MoHURD-supported eco-cities programme. Besides guidance, the document will help to ensure compliance of cities with the normative part proposed under this guideline.

Legal Basis. This Eco-City Implementation Guideline is complementary to the existing urban planning legislation of the People´s Republic of China (PRC), and other guidelines of the Ministry of Housing, and Urban-Rural Development (MoHURD), particularly those pertaining to eco-city development. The relevant legal reference documents are:

- Urban Planning Law. 1984. In 2008 updated as “The Urban and Rural Planning Law of People’s Republic of China”; latest revised in April 2015.
- Land Management Law. 1998.
  And based on the law, the detailed Enforcement Regulation has been developed, and undergone revisions for several times. The latest is the 2014 version.
- Environment Protection Law. 1990. Latest revised in 2014 and applied since 2015.
- MoHURD. March. 2013. The 12th 5-Year Plan on the Green Building and Green Ecological Districts.
- CCPCC and State Council. March, 2014. National New-type Urbanization Plan 2014-2020.
- State Council. April, 2015, Suggestions on Enhancing Eco-civilization.
- CCPCC and State Council. 2016. Central Government Guideline on Urban Planning.
- CCPCC and State Council. 2016. The thirteenth Five-Year Plan (2016-2020)

Specifically to the water sector, the following legal instruments apply:

[1] EC Link Toolbox. 2016. *Green Building*. Beijing. Draft English version. www.eclink.org.

- Law for Water Pollution Prevention. 1984.

Significantly revised 1996 and 2008. Undergoing revision again

- MoHURD. 2014. Guidelines for the Sponge City (Low-Impact-Development).
- State Council. 2015. Guidelines for Promoting Sponge City Construction (usually referred to as “File No. 75)”.
- State council. 2015. Action Plan for Urban Water Management (usually referred to as Water Ten Point Plan)

This Eco-City Implementation Guideline is *mandatory* for all Chinese cities which are participating in the national MoHURD-supported eco-cities programme. Compliance with its missions and technical targets will be monitored and reviewed by MoHURD. Compliance will be rewarded through special allocation of funding and technical implementation support.

Scope of this guideline. The geographical scope of this Eco-City Implementation Guideline are urban areas as defined by the existing legislation. The application of this Eco-City Implementation Guideline may be extended to Districts which are under the jurisdiction of a city (urban area), as applicable.

Substance of this guideline. This Eco-City Implementation Guideline is dedicated to Water Management (WM) - Water Supply, Waste Water Treatment, Drainage and Storm Water Management. The implementation of eco-city development approaches concept makes it necessary to deal with these different dimensions of water management. To implement a water management agenda it will be necessary to have committed city and district governments so rules can be enforced.

Water Supply

Water a scarce resource. Water is a scarce and undervalued resource. In terms of public health and sanitation, the provision of piped water to households and industry can be transformational for societies. Conventionally this is provided by municipalities developing water infrastructure to abstract water from rivers or groundwater, adding some preliminary screening or filtration treatment and developing water supply pipe networks. Initially this may be to public taps, and latterly into individual homes. Treatment facilities are progressively improved. Because of this early evolution water supply to established cities was seen as a stand-alone engineering issue. However, pressures to over abstract from scarce water resources, water quality deterioration in rivers and groundwater, combined with high cost has made this unsustainable in some cases. This has given rise to the more integrated thinking seen through water-sensitive urban design (WSUD) and the sponge city concepts which encourage water saving, smart technologies supply management, improved waste water treatment, and low impact development (LID) in drainage facilities and flood control measures which can additionally enhance water harvesting and water recycling.

From traditional water supply to non-conventional methods. From a perspective of eco-city development, water supply cannot be limited to the simple supply of water in a specific location, its affordability or quality of service. From a perspective of resource efficiency, it is paramount to go beyond access to safe water – as a key requirements for safe and healthy living – towards maximizing the available water resources. Since drinking water has become a finite resource, the generation of water from non-conventional sources such as rainwater harvesting or recycling of water, i.e. the use of renewable and sustainable resource, will assume a new dimension in the future development of eco-cities. Rapid urbanization and climate change have impacted the quality of water resources and the regularity of supply and access. Demand-side issues involve more than just the provision of potable water: with increased population comes increased demand for water especially in the agriculture and industry sectors.

The water cycle. Water supply cannot be considered in isolation. Waste water treatment, drainage and flood control (or ¨stormwater¨ management), as well as solid waste management need to be seen as integral elements of water management. The lack of wastewater collection and treatment (often combined with poor or absent legislative provisions) has detrimental impact on water supply. Poor practices and the lack of enforcement of appropriate wastewater collection and treatment exacerbate the contamination of water supply which, in turn, contributes to the spread of waterborne diseases that pose health risks to users.

Systems approach for the water sector. Today´s vision of the water sector, is very much influenced by the concept of integrated water resource management (IWRM). IWRM is a systems-based approach to managing water resources. It considers watershed (also termed ´river basin´) management and water harvesting at various points, and how this impacts the health and access to the water resource. In addition to the environmental dimensions, IWRM also considers social and economic factors.

Ecological footprint. For eco-cities, depending on the environmental profile of each city, IWRM is likely to extend beyond city boundaries and potentially across multiple administrative areas. It considers the ecological or environmental ¨footprint¨ of this sector. It also highlights the importance of institutional and legislative conditions since these do affect actions upstream and downstream. Environmental impacts, for instance by large scale water usage of a city, will be felt in its surroundings, and will influence the ecological ¨footprint¨ of a city.

Safe and secure water supply. ¨Water security is a significant challenge for cities in the 21st century. Water security refers to the ability of an area to access, retain, and maintain acceptable quantity and quality of water to support its full range of activities. Such requirements are becoming increasingly more difficult as the impacts of population growth, city growth, and environmental degradation are experienced. The five key dimensions for Asian cities are household security, economic water security, urban water security, environmental water security, and resilience to water-based disasters.[2] Together, these capture the multiplicity of water in people's lives. Water security also highlights the importance and challenge of providing water that is fit for its purpose. IWRM is an approach that considers how a city or urban area fits within a wider context (catchment area) and what factors influence water security, thus enabling appropriate planning and mitigation measures to be developed.¨[3]

Waste Water Treatment

Environmental Sanitation. Environmental sanitation or management encompasses disposal and treatment of waste waters. This requires an integrated management approach at neighbourhood or city level. At the household level there is of course also the safe management of human excreta, which includes the provision of toilet facilities, in combination with education and behaviour change promoting hygienic practices (e.g., hand washing) to reduce fecal–oral diseases.

Centralized versus decentralized systems. Many cities have become oriented towards ¨high-tech¨ solutions of centralized collection and treatment systems. Water supply on the one hand, and waste water collection (sewerage system) and treatment are two sides of the same coin. Urban areas which lack the necessary infrastructure to collect, treat, and dispose of wastewater face numerous human and environmental health problems. Environmental sanitation is necessary for proper management of urban environments and to improve and protect human health as well as the natural environment.

Water for sanitation. Water is an essential ingredient for sanitation practices, while waste water collection is required to enable capture, treatment, and disposal of waste in appropriate manner. It will ensure water sources are not contaminated and environments not degraded. For a holistic approach to water and sanitation, there needs to be simultaneous development of water supply and a (centralized) sewerage system or means of (decentralized) collection of wastewater (septic tanks/septage system). Consideration must also be given for the type of facilities which are to be introduced, centralised or decentralised. Population, density, topography, the natural environment, and potential cost of the investment are factors that will influence this decision.

Inadequate collection of waste water. Inadequate collection of waste water has a very strong impact on the natural environment. More so, the discharge of untreated effluent and

[2] Baird, A., and Esteban, T.A.O. Green Cities: A Water Save Future. In: Lindfield, M. and Steinberg, F. (eds.). 2012. *Green Cities*. Manila: Asian Development Bank. Urban Development Series. Manila. pp. 218-261. http://www.adb.org/publications/green-cities

[3] ADB. 2013. *Asian Water Development Outlook 2013. Measuring Water Security in Asia and the Pacific*. Manila.

industrial waste has strongly detrimental effects on the biology of watercourses and their ecosystem. Contaminated freshwater sources, degraded aquatic environment, and eutrophication through excessive nutrient discharge are all outcomes of poor wastewater and surface water management. Coupled with these challenges, inadequate drainage and preparedness for heavy rain events often means that wet season and instances of high rainfall are compounded by poor or absent solid waste management and exacerbate the challenges that cities face in managing water resources, as it impacted by through localized flooding, contamination of water resources (through effluent combined fresh water).

Improving the fiscal base for waste water treatments. In many cities, waste water treatment is not adequately covered because, the costs for waste water treatment are not covered by revenues. Many cities do not collect (adequate) fees for waste water. The opportunity to charge for this through combined billing with the water bills often times is lost, due to politically minded decisions. Improving the fiscal base and capacity for wastewater collection must be considered in the context of green cities as functional and well-maintained sewerage system represents a fundamental building block of green city development.

Drainage and Flood Control **Drainage and flood control the third leg of the water sector.** Drainage and flood control is the final and important element of the water sector. The capacity of a city to cope with rainfall, drain effectively, and maximize opportunities for stormwater collection and reuse is essential for the long-term sustainability of cities. Drainage and flood water management is multifaceted and closely linked to adequate infrastructure. Inadequate drainage and flood control is most pronounced in urban areas that own rivers, and are located on or near floodplains or low-lying areas. Many Chinese cities have these characteristics and, as a consequence, many citizens, often in poorer neighbourhoods, are regularly impacted during seasonal rains and heavy storm events.

Negative impacts of rapid urban development. Rapid urbanization, incomplete urban planning and building control, and constraints of institutions and in fiscal capacity of cities means that many cities do not have adequate drainage and flood control systems in place. Conversion of land to urban uses through building construction and provision of infrastructure such as roads means pervious surfaces become less able to absorb when concrete and asphalt are used. This affects the flow of water and drainage capacity of an area. Often, drainage systems are absent and rain or flood water is not directed, captured, treated, and discharged appropriately. As a result, localized flooding occurs, and the quality of water resources diminished as a result of pollution.

Maintenance of drainage and flood control infrastructure. Similarly, drainage systems can be poorly maintained and clogged with waste, thus becoming ineffective. Drainage and flood control need to be considered within a holistic system of water management that recognizes the influence of urban drainage within the wider context of watershed management, flood control, environmental health, and water treatment and reuse.

Sustainable Drainage Systems. The so-called Sustainable Urban Drainage Systems (SuDS) are a sequence of water management practices and facilities designed to drain surface water and to mimic natural drainage. Practices refer to improved land use planning and location of potentially polluting activities, water harvesting, and improved urban design and building standards. Facilities refer to the use of permeable surfaces; green infrastructure such as wetlands, filtration and infiltration systems, swales, and detention basins; and underground storage. The SuDS management (SusDrain) is an approach that aims to maximize the benefits of SuDS and to incrementally manage pollution, flow rates, and volumes of water runoff. The SuDS management considers the following steps:

- Prevention: Considers site design, land use planning, and pavement and built area surfaces to reduce and manage runoff and pollution.
- Source Control: Runoff managed as close as possible to the source—management techniques include the use of green roofs, rainwater harvesting, permeable paving, and filter strips.
- Site Control: Runoff managed in a network across a site or local area through the use of swales, detention basins, etc. These public realm solutions also fulfil a multifunctional green infrastructure role.
- Regional Control: Downstream management of runoff for whole site/catchment, such as retention ponds and wetlands.

Resilience of cities to climate change. As many European and Chinese cities are close to coastal areas, rivers and large water bodies, the chances of becoming affected by severe rainfalls and extreme weather situations are very pertinent. The threat of climate change impacts is serious. Hence it is very important for coastal cities to increase their preparedness and resilience to the possibilities or regular large scale flooding. In the case of European cities, even inland cities have been affected in recent years by flooding caused by extreme weather events. China, on the other hand has seen frequent inundations in coastal cities, and very damaging typhoons happening prac*tically on an annual basis. In this context the concept of absorptive capacity, the ¨sponge city¨ has been introduced to illustrate such capacity.*

The ¨sponge¨ city. For thousands of years city planners have engineered water into submission. This is the core of modern infrastructure, a concept derived from ancient times. Collecting water somewhere on the outskirts of the city, sending it with gravity into the city, and when it has been utilized, we put into the ground, in sewers and send it away. Most cities are designed according to this concept. However, surplus rain water is not kept and stored, and stormwater – another form of surplus water was kept neither. In the ¨sponge¨ city approach, surplus water is stored for consumption, and flood waters are diverted to storage, and possible later uses.[4]

In China a current major theme is the development and implementation of 'Sponge City'-initiatives. This is driven by MoHURD and central government grants are provided for cities that apply for and win 'Sponge City' Status. Other terms are used to describe and align similar initiatives in other countries.

[4] Building Sponge City: Redesigning LA for Long-Term Drought.
http://www.npr.org/2015/01/22/378844314/building-sponge-city-redesigning-la-for-long-term-drought

Green infrastructure. Green infrastructure in urban areas includes addressing issues (such as drainage) that traditionally have been addressed through hard engineering solutions (capture, redirection, and discharge). Green infrastructure considers natural processes and, in the case of drainage, sustainable drainage systems to incorporate the use of permeable materials and landscaping. This response may be integrated into open space networks including walkways and cycle paths. Responding to climate change and reducing vulnerability of communities are key considerations for provision of resilient infrastructure and are included within the understanding of green infrastructure. Green, resilient infrastructure considers both hard and soft engineering solutions.

Justification.

The Water Challenges Facing China. A study of 2009 found that urban demand for water will increase by between 65% and 100% over the next 20 years as the economy grows and as urbanization continues at a rapid rate. The principal driver for this increase will be a tripling in residential water use. The shape of China´s urbanization will also have a significant impact on water demand and the investment needed to satisfy the demand. In a supercities scenario, urban water demand would double by 2025 and China would have to invest an estimated 1.1 trillion renminbi in its water supply infrastructure. In a townization scenario urban water demand would increased by 70% from 2005, significantly less than under supercities. The amount China would need to spend on its urban water supply infrastructure would vary even more significantly – by 40% - between supercities and townization. [5] 'Water Use is very likely to be a severe challenge, particularly for the Mega-cities in the North that will need water transfer projects to meet their needs. However, it is fair to note that most water consumption will still be in agriculture.' The overall cost of the water issues has been estimated at 2.3% of GDP, mostly reflecting damage to health. Water shortages also imperil plans to expand energy production, threatening economic growth.[6]

[5] Source: McKinsey Global Institute. 2009. Preparing for China´s Urban Billion. http://www.mckinsey.com/insights/urbanization/preparing_for_urban_billion_in_china
[6] China Water - All dried up. *The Economist.* Oct 12th 2013.

Development Objectives

Water Resource Strategy and Reform. China No. 1 Policy Document on water resources reform (No.1 Document, 2011) focuses on 'accelerating water conservancy reform and development' and commits expenditure of 4000 billion Yuan on water infrastructure over the next ten years.[7] The document focuses on water security, but maintains the links to food through stressing the importance of water reform to food production. This is a fundamental link as 68% of the available water in China is used in irrigation and food production. Another first for China is that water resource reform is seen as a long term commitment and the fact that the water reform and committed expenditure span two five year economic periods demonstrates a strong political will to place water at the top of the government agenda. China will drive significant steps to improve water security and to invest in water infrastructure over the next ten years. China recognises the crucial role that water plays in rural and urban development. Water security for food production sits as a top priority for the nation of 1.35 billion people. It also recognises the risks of extreme events associated with a changing climate and has experienced the impacts of extreme flood and drought events more than most western societies. Historic links to water and the focus of cultural development around the major river systems is important to China and influences the approach to water management.

Policy Direction from the 13th Five Year Plan. The Government´s pronouncement of the Five Year Plan objectives has stated three key objectives:

- Increased efficiency of energy resources development and utilization; effective control total aggregate of energy and water consumption, construction land, and carbon emissions. The total emissions of major pollutants shall be reduced significantly.
- City development shall be in accordance with the carrying capacity of resources and the cultural context. Green planning, design and construction standards shall be applied.
- Support reduced emission standards, and implement demonstration projects of ¨near-zero¨ carbon emission.

New Urbanization Policy 2016. Following the Central Urban Work Conference (20-21 December 2015) - the second such meeting on the issue 37 years after the first meeting in 1978 - on 6 February 2016, the Communist Party of China Central Committee and the State Council issued a roadmap for city development. Its key points are as follows [8]

- **Strengthen the city planning.** Within about 5 years, assess and deal with all illegal constructions; introduce absolute restrictions on new illegal constructions.
- **City form and features.** Within about 5 years, identify historic cultural blocks & historic building in all cities.
- **Improve the urban building**. Within 10 years, increase the rate of prefabricated buildings to 30%.
- **Promote the development of energy conservation in the city**. Promote the district combined heat and power (CHP), green lighting, energy conservation in government departments; improve heat production efficiency; newly built residential

[7] Central Committee of the Communist Party of China (CPC) and the State Council (eds.). 2010. The China No.1 Water Document 2011.
[8] Extracted and translated from: http://www.gov.cn/zhengce/2016-02/21/content_5044367.htm)

buildings must be equipped with individual measurement of household heating consumption, while that shall be gradually provided for existing residential buildings.

- **Complete urban public service**. The development of public transport enjoys priority. Until 2020, the share of super- and ultra-large public transport will reach 40%. Newly built communities would get open rail systems (instead of closed ones). [9]
- **Build comfortable and livable environment.** Within 5 years, set up the system of collection and reutilization of kitchen and building waste. Until 2020, in all cities above prefecture level, waste water shall be 100% collected and treated; for water deficient cities, the reclaimed water rate shall reach 20%.

China Development Bank Capital (CDBC) Policy for Green Urban Development. The CDBC´s policy document for Green Urban Development states several principles for the green building sector:

- **Water Efficiency:** All buildings must have 100% adoption of cost-effective water saving appliances, and green spaces surrounding buildings must adopt low water-use plants. All water consumption should be metered and at least 20-30% of water supply must be recycled from either wastewater or rainwater. [10]
- **Smart Technologies can advance green development:** Save water through IoE technology and other water saving technology. Cities can improve water efficiency through smart storm and flood control equipment and water re-use. [11]

Relationship between Smart and Green Guidelines

Smart Guideline	Relevant Green Guidelines	Relationship	Relevant Smart Technologies
Smart Governance	Water	Using data to manage water in an urban area can greatly improve efficiency by detecting leaks or identifying the most inefficient water users.	Smart Water Management

Source: China Development Bank Capital (CBDC). 2015. *6 Smart Guidelines. CDBC´s Green and Smart Urban Development Guidelines*. Beijing (draft). http://energyinnovation.org/wp-content/uploads/2015/11/Six-Smart-Guidelines.pdf

Challenges of water management. Comprehensive water supply, wastewater collection and a reasonable degree of wastewater treatment infrastructure are in place. Here the aim is to attain the value for money and capital and operational efficiency of the best examples from OECD countries. Capital maintenance will be an increasing challenge for water companies in major cities as older assets serving the city centre deteriorate and compete for capital investment with the need to extend services to non-core areas of the city and meet tightening environmental and service standards. The water utilities are generally financially independent companies or departments financed operationally by user fees; infrastructure investment is via municipal, provincial and state funds. There is a rapidly growing private sector providing investment and management services to municipal water

[9] See debate about this issue in China Daily http://www.chinadaily.com.cn/china/2016-02/22/content_23593906.htm).

[10] China Development Bank Capital (CBDC). 2015. *12 Green Guidelines. CDBC´s Green and Smart Urban Development Guidelines*. Beijing (draft). http://energyinnovation.org/wp-content/uploads/2015/12/12-Green-Guidelines.pdf

[11] Source: China Development Bank Capital (CBDC). 2015. *6 Smart Guidelines. CDBC´s Green and Smart Urban Development Guidelines*. Beijing (draft). http://energyinnovation.org/wp-content/uploads/2015/11/Six-Smart-Guidelines.pdf

utilities through a range of contractual and asset transfer methods. Overall massive investment in water services is required in China, especially in the second-level cities and in wastewater collection and treatment and pollution control. There is also a particular need for investment in sludge management to ensure that the pollutants removed from the wastewater do not re-enter the environment in an even more harmful form, but can instead be put to beneficial or at least harmless use.[12]

Management of urban water supply. This is the responsibility of "cities" under arrangements that differ substantially from one city to the other. The term "City" has a dual and confusing meaning in China. It is used here to refer to the main urban area of a municipality, prefecture, or county. Cities are governed by a "leading group" under the leadership of a mayor, who is assisted by various "bureaus", or departments. Services are usually provided by municipally owned water bureaus and wastewater bureaus (sometimes referred to as utilities despite the relatively limited autonomy that these companies enjoy). Water and wastewater bureaus are typically separate from each other. In larger cities, services are further unbundled: There may be a separate raw water bureau that transports water from far-away sources and sells it to the municipal water bureau for distribution. Likewise on the wastewater side, larger cities may have several district drainage bureaus in charge of parts of the city, a wastewater bureau in charge of the main collectors, and a third bureau in charge of wastewater treatment. In some cities, the various companies are under the same "parent bureau", which may be the construction bureau or a water bureau, while in other cities the water bureau and the wastewater bureau report to different parent bureaus. Especially in smaller cities the county administration provides services directly.

Water Supply. Water supply and sanitation in China is undergoing a massive transition while facing numerous challenges such as rapid urbanization, a widening gap between rich and poor as well as urban and rural areas. Water scarcity, contamination, and pollution in China also pose great challenges. Much has been achieved during the past decades in terms of increased access to services, increased municipal wastewater treatment, the creation of water and wastewater utilities that are legally and financially separated from local governments, and increasing cost recovery as part of the transformation of the Chinese economy to a more market-oriented system. Nevertheless, much remains to be achieved. Many Chinese still did not have access to an improved water source, nor access to improved sanitation. Progress in rural areas appears to lag behind what has been achieved in urban areas. Many water users receive water at inadequate pressure, and about 60% of China's cities face seasonal water shortage, and severe water constraints. Currently, China is facing a shortage of water due to climate change and rapid development. The government has issued in 2013 water quotas to every province, setting targets for annual consumption.

Groundwater Protection. Cities must coordinate to protect their water. Excessive exploitation of groundwater and the reduced volume of storage capacity have aggravated the instability of the water ecosystem. Due to their geographical location and climate, many cities suffer from a natural shortage of water supply. Also pollution has become a major water problem, with industrial activities and a large number of informal waste dumps

[12] OECD 2009, OECD Reviews of Regulatory Reform: China Defining the Boundary between the Market and the State. Chapter 7 Water. Paris

contaminating water sources. Many cities have resorted to excessive pumping of from groundwater resources. This may lead to a destabilization of soils, and dangers to the high density construction in large cities, like Beijing, Tianjin-Hebei.

Water Safety Plans. The WHO recognizes water safety plans (WSPs) as a comprehensive framework to assure the quality of drinking water through systematic assessment and management of health risks. WSPs are management plans that are developed and implemented by water suppliers. A WSP is primarily a tool used to address the safety and quality of water, while its measures for control and improvement address the quantity of water and water security, including water resource management to minimize system losses. These plans were introduced because the traditional curative approach was no longer reliable in addressing the public health aspects of managing the quality of drinking water. Action was taken after results of adverse water quality tests, consumer notification of water quality problems, or even disease outbreaks.

Public toilets China. In general, public toilets are maintained to a high standard in Chinese cities. These provide important facilities for washing and toilet, especially in older suburbs and *hutongs* where individual toilets are not provided. In some situations, both urban and rural in China, public toilets are provided but may not have sufficient water supply, are inappropriately located, are not maintained, and/or may not be suitable for use by women (particularly when dark). Similarly, many households that share one toilet may face similar problems with water supply and waste collection. Good sanitation practices are essential the environmental health performance of cities.

Waste Water Treatment. It has been estimated that in 2010 there has been sufficient capacity to treat 73% of urban residential wastewater, and the total of urban sewerage of 82%. The most commonly used technologies were various forms of activated sludge, including oxidation ditches (24% of all plants), sequencing batch reactors (11%), conventional activated sludge (5%) and membrane bioreactors. In small communities, plants using only primary treatment were still common (15% of all plants). Most plants operate in compliance with discharge standards.

Water Pollution. In April 2015, the government declared that will wage a war against water polluting industries. This was declared in spite of fears that local governments and industries would oppose the move towards more environmental control of polluting industries, due to cost increases. This move will mean the levying of heavy fines for polluters, and the threat of eventual shut-down of industries. The government is convinced that positive impacts of greener and cleaner industries will eventually translate into a tremendous growth as the iron and steel making industries will become internationally competitive, and that benefits reaped could be in the order of 5.7 trillion RMB ($910 billion), in the industrial sector, and 3.9 million non-rural jobs.[13] The Action Plan for Water Pollution wants to contribute to make more than 93 % of water drinkable. Factories which are too weak to comply with these regulations will be shut down from 2016 onwards.

From 2016 onwards, the government will establish a blacklist of polluters. The amount of black and smelly water in urban areas will be reduced to 10% by 2020, and should largely disappear by 2030, according to this Action Plan for Water Pollution. To reach these goals,

[13] Nation wages war on water pollution. 10 most polluting industries targeted. in: *Global Times.* http://www, and: Water pollution targeted by new plan. In: *China Daily.* 17 April 2015.

outdated production capacity will be phased out in water polluting industries, the efficiency of water use will be will be increased, and market forces will be allowed to further optimize water consumption. The greening of the water sector is considered to become a possible additional engine of economic growth.

Massive investment program for wastewater treatment. Over the past 20 years, China has engaged in what is possibly the largest program to build wastewater treatment plants in history. Despite the substantial achievements of this program, many challenges remain. The designs of treatment plants were sometimes inappropriate, as there was no requirement for pre-treatment of industrial effluents thus affecting the effectiveness of treatment processes. Sites chosen for the first priority investments within a river basin were not always those where the highest impact could have been achieved in terms of improving river water quality. As a result, some plants are underutilized or poorly functioning. Consequently, the impact of the investment program on the water quality in rivers and coastal waters has been limited.

As a result of these developments, municipal and industrial water use actually declined because of low increases of connection rates to utilities because of underestimation of the importance of small-scale water providers, increased tariffs, increased metering, industrial restructuring, measures to increase the efficiency of water use in industries, as well as due to water scarcity and drought. Many Chinese water and wastewater companies have overcapacities and are in financial difficulties because the revenues are insufficient to cover the servicing of the debt contracted to build the oversized infrastructure.

Drainage and Flood Control. In recent years, heavy rains, floods and gradually evolved into a chronic disease of large and medium cities. Today, 99% of Chinese cities are in the fast discharge mode. Rainfall on the hardened, impermeable ground only relies on fast discharge through pipes. When there are strong rains, quickly it is obvious that under-dimensioned pipes are not enough. Many of the cities do have serious shortcomings in water supply, but rain water is usually just quickly drained away. Large dis-economies of the water sector exist, considering that more than 70% of water has to be brought from areas outside the cities.

China Sponge City – Strategic Initiatives. China has developed a strategic initiative to reduce surface water flooding and improve water resource security. It is known as the Sponge City initiative. The sponge City initiative aims to show that urban drainage and water shortages could be turned around to harvest this wealth of the existing water resources. Thus, the concept of the sponge city, is an analogy of ecological water management: rainfall can be absorbed locally or nearby, be saved in storages, infiltrated, purified, and used water can be fed back into the groundwater after (decentralized) cleaning. The sponge city concept will allow improved regulation of the water cycle: in drought when water is in short supply, it can be released, and it can be stored when in oversupply. The construction of sponge cities implies a reversal of concepts. Traditional city-building has used too many hard surfaces with fast run-offs of water. At the time of rain, this relies on drainage infrastructure, pumping stations and other ”grey” facilities for drainage which mean to eliminated water excess rapidly, instead of being conducive to its usage. Eco-city development should give emphasis to soft surfaces (permeable surfaces), such as grass, rain gardens, sunken green spaces and other “green” measures to organize drainage to slow the draining and release, of water. It suggests decentralized control of the water and waste water.

The physical implications of the ¨sponge city¨ concept would be a series of water bodies - rivers, lakes, ponds, green spaces, gardens, permeable pavements, and cavernous underground structures for water storage. While this concept may be feasible in new districts (¨greenfield¨ development), in urban renewal (¨brownfield¨ development) it is more complicated and costly to introduce, as observed by the China Academy of Urban Planning and Design. Nevertheless, there exist ideas about the application of the sponge concept in historically grown built environments, through rain gardens, sunken green, combined roads-cum-green belts, permeable paving, and green roofs.[14] These green initiatives are gaining traction in China and are labelled Sponge Cities. The first batch of the 16 'sponge cities,' including Zhuhai, Wuhan, Chongqing, Xiamen, Zhenjiang and others, will set up systems to allow rainwater to be stored and purified using a permeation system. Each of the 16 so-called 'sponge cities' is going to be allocated between 400 and 600-million yuan for their various projects every year. [15] These low impact initiatives develop and incorporate the core ethos of Eco-city design, Sustainable Urban Design and Water sensitive cities. They align directly with the aims of the Eco-cities concepts discussed above.

Cost recovery policy for water supply and sanitation. It is the government's policy to fully recover costs for water supply and sanitation through user fees, and that water tariffs should be volumetric. The MoHURD oversees financing for urban water and sanitation infrastructure as well as policies concerning the regulation of water and sanitation utilities. The ministry of construction has issued some important policy papers on this topic of cost recovery,[16] however, there is no law concerning the regulation of public utilities or private sector participation in the sector. The Ministry of Health has attributions related to the promotion of rural water supply and sanitation.

Private sector participation in water management. Private sector participation in financing infrastructure and managing services is widespread. Today, there are dozens of water projects and well over 100 wastewater projects in China with private sector participation, many of these with foreign partners. An econometric study by Chinese economists on the impact of private sector participation on the performance of urban water supply in 35 major cities over the period 1998 to 2008 found that " the participation of foreign companies, but not domestic private companies, significantly improves water industry performance".

Build-Operate-Transfer (BOT) contracts. The most common form of private sector participation in water supply and sanitation is through Build-Operate-Transfer (BOT) contracts where the private sector is in charge of large upstream or downstream infrastructure without being directly involved in serving users. Experience with BOT contracts has been mixed.

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[14] Department of Housing, Urban and Rural development, Promoting the " sponge city" : The next big rain again will not "see the sea", http://www.enews163.com/2014/11/03/department-of-housing-and-pushing-the-sponge-city-the-next-big-rain-again-will-not-see-the-sea-89687.html; see also: The New Mindset – Interview with Qiu Baoxing, in: *Green magazine*. Chinese Society for Urban Studies. No.10, 2015, Beijing. pp. 25-31. http://weibo.com/greenmagazine

[15] See 'Sponge city' initiative, China Daily, 20 July 2015. http://www.chinadaily.com.cn/china/2015-04/20/content_20481352.htm

[16] "Accelerating the Marketization of Public Utilities" (No.272 Policy Paper of the MOC, 2002), the "Measure on Public Utilities Concession Management" (No.126 Policy Paper of the MOC, 2004), and the "Opinions on Strengthening Regulation of Public Utilities" (No.154 Policy Paper of the MOC, 2005).

Transition to commercial utilities. In 2002, the Ministry of Construction issued a policy paper on the commercialization of public utilities. Subsequently, in October 2003, the central government decided that state-owned enterprises had to be separated from Ministries and/or provincial governments and had to be commercialized. Competitive bidding for contracts, private sector participation and commercial financing are important element in the transition to a market economy. In the 1990s, the first BOT contracts were signed for wastewater treatment plants. More than 200 wastewater treatment plants were built with some form of private sector participation in their financing and/or management, usually using the BOT formula. Early BOTs saw governments implementing the process without the benefit of financial, legal, and technical advisers, finding to their chagrin that the process becomes more complex in the absence of expert knowledge. Learning from the experience of past BOTs in the sector, local governments sought expert advice on bidding and public tender. In about 2000 for the first time, a BOT water project (Chengdu No. 6 Water Supply Plant) was awarded on the basis of transparent international competitive bidding, with support from the ADB. In 2004, a landmark international competitive bid for the entire water supply and sanitation system of Shenzhen was won by a joint venture including the French firm Veolia.

Water Efficiency Measures. There are many different indicators for utility efficiency. In the case of China, some indicators, such as labour productivity, suggest a low level of operational efficiency, while other indicators - such as non-revenue water - suggest a high level of operational efficiency. Most water and sanitation utilities in China have a low labour productivity and are overstaffed. Non- revenue Water - consisting mainly leakage losses in the distribution network - are estimated by the Chinese Waterworks Association to be only 20% on average and less than 10% for the best utilities, which is very low by international standards. The International Benchmarking Network for Water and Sanitation Utilities estimated the non-revenue water for a sample of Chinese water utilities at 27% in 2006 and 21% in 2001. One explanation for the relatively low level of NRW may be that most Chinese live in dense apartment complexes, which results in compact distribution systems. In some smaller cities, non-revenue water remains relatively high.

Tariffs and cost recovery. Cost recovery for water and sanitation services paradoxically is lower in urban areas, while it is higher in rural areas, despite the lower incomes of rural residents. Many urban water and wastewater utilities in China experience financial stress, because user fees are set well below cost recovery levels and government subsidies are insufficient to cover the resulting gap. Urban water tariffs have been were very low and sewer tariffs were practically unknown until this was changed in 1998 with the adoption of National Guidelines on Urban Water Tariffs. Subsequently, water tariffs have been increased substantially in many Chinese cities, particularly in the north where water is scarcest. However, water tariff reforms have not been effective enough to offer the necessary incentives to save water. While many cities now have sewer tariffs, in many cities across the country no wastewater treatment fee is collected. China has a policy of universal metering, including metering of individual households in apartment complexes, where most urban residents live. Metering in urban areas is now relatively widespread with an average of 90% connections being metered. Some cities are experimenting with pre-paid debit cards that residents must put into their meters in order to receive service. Tariff structures are complex, with different tariffs for different categories of users and higher tariffs charged to industrial and commercial users than to residential users. Most water tariffs are linear, i.e. there is a single price per unit of water, although there are some increasing-block tariffs where the unit price increases with consumption. Urban tariffs are

approved by Price Bureaus of cities, after considerable prior negotiation. Tariffs do not require approval from a higher level of government.

Proposed Water Management KPIs [17]

	Water Management (Water Supply, Waste Water Treatment, Drainage and Storm Water Management)		
	Indicator Category	**Indicators: indicative values**	**Current achievements / Time frame for accomplishment**
1	Quality of water bodies [1]	Grade IV surface water quality standard GB 3838-2003 [1]	By 2020
2	Water quality at centralized source reaches standard [2]	100% [2]	
3	Water quality at user level [2] Services network coverage [1]	100% [2] 100% [1]	` By 2013 [1]
4	Water from taps with drinking water quality [1] Drinking water Grade III standard [3]	100% 100% [3]	immediate
5	In buildings: adoption of cost-effective water saving appliances [4] Water leakages as per standard CJJ92 [5]	100% [4] ≤8 % [5]	By 2020 [4]
6	Rate of reuse of reclaimed water (%) [2]	In water-scarce areas ≥25%: in areas without water scarcity ≥15% [2] ≥60% [6] Water deficient cities: ≥20% [7]	
7	Domestic water consumption [1]	≤ 120 liters / day.pers.[1] Not higher than the average of lower & upper limits of GB/T50331 [5]	By 2013 [1]
8	Water supply from non-traditional sources [1] Water supply from recycled wastewater or rainwater [4]	≥50% [1] 20-30%[4] ≥85% [18] ≥10% [5]	By 2020 [1]
9	Water permeability of surface areas [8]	≥50% [8]	
10	Wetland conservation [5]	≥80% [5]	
11	Sanitation coverage, waste water treatment [7]	100% [7]	By 2020 [7]
12	Grey water treatment and reuse	50%	By 2020
13	Sponge city infrastructure contributes to water harvesting	30% of water supply	By 2020
14	Drainage and sponge city measures eliminate urban flood events	100%	

Sources:

[1] World Bank. 2009. *Sino-Singapore Tianjin Eco-City: A Case Study of an Emerging Eco-City in China.* Technical Assistance Report. Beijing. www-wds.worldbank.org/.../PDF/590120WP0P114811REPORT0FINAL1EN1WEB.pdf

[17] These key performance indicators were prepared and compiled by the EC-Link Project. See: EC-Link. 2016. *Sino-EU Key Performance Indicators for Eco-Cities*. Beijing (unpublished draft)

[2] Qiu Baoxing. 2012. Combine idealism and pragmatism – a primary exploration of setting up and implementing low carbon eco city indicator system in China [in Chinese], China Construction Industry Publisher. Beijing
[3] Ministry of Environmental Protection (MEP). 2008. Indices for Eco-County, Eco-City and Eco-Province. In: World Bank. 2009. *Sino-Singapore Tianjin Eco-City: A Case Study of an Emerging Eco-City in China.* Technical Assistance Report. Beijing. www-wds.worldbank.org/.../PDF/590120WP0P114811REPORT0FINAL1EN1WEB.pdf.
See also 2013 version. http://www.mep.gov.cn/gkml/hbb/bwj/201306/t20130603_253114.htm
[4] China Development Bank Capital (CBDC). 2015. *12 Green Guidelines. CDBC´s Green and Smart Urban Development Guidelines*. Beijing (draft). http://energyinnovation.org/wp-content/uploads/2015/12/12-Green-Guidelines.pdf
[5] MoHURD. 2015 and 2016 versions. *Appraisal Standards for Green Eco-City/District Planning (draft)*. Beijing [Unofficial Translation].
[6] CSUS. 2015. Zhuhai Indicator System for Livability. Beijing. [unpublished report].
[7] State Council, Government of People's Republic of China. 2016. 13th Five Year Plan. Beijing.
[8] MoHURD. 2005. National Standard for "Eco-Garden City". In: World Bank. 2009. *Sino-Singapore Tianjin Eco-City: A Case Study of an Emerging Eco-City in China.* Technical Assistance Report. Beijing.
www-wds.worldbank.org/.../PDF/590120WP0P114811REPORT0FINAL1EN1WEB.pdf.
See also 2010 version. http://www.mohurd.gov.cn/wjfb/201012/t20101228_201748.html

Future issues for water optimisation in eco-cities

Number	Issue	Suggested Intervention
1	**Water Security** Ensure future water security for city Consider key elements of European Union (EU) Blueprint for Water Security	Assess risks and develop long term water strategic plan taking into account supply and demand balance and options to reduce risks. Linked to city masterplans Also consider flood mitigation and the use of 'making space for water' options Ensure water is not polluted and is fit for purpose through regulation (see 4 and 5 below)
2	**Climate Change** Climate change adaptation strategy	Linked to the above, but taking into account changing weather patterns, sea level rise and population growth. Scenario planning approach should be developed
3	**Quality Water Supply** Provision of high quality drinking water for all citizens. (Probably the greatest potential public health improvement.) Adopt World Health Organization (WHO) minimum standards and EU Drinking	Overall assessment of current drinking water provision and infrastructure. Plan, cost and develop infrastructure plan for the city to

	Water Directive equivalent	provide this according to a phased plan. Assess benefits including public health improvements.
4	**Waste Water Treatment** Improvement and optimisation of dirty water systems – primary pollution control EU Urban Waste Water Directive minimum standards	Provision of high quality sanitation for all – in homes and through public toilets in the interim. Assessment of current infrastructure and sewerage systems, especially combined sewer overflows and foul sewage discharges. Plan to stop all untreated discharges under normal operations Assess municipal sewage treatment provision and future need, including enhancements to provide improved water resources and environmental clean-up
5	**Industrial Pollution Control** Regulation and permitting of abstractions and industrial discharges. Suggest using EU´s Network for the Implementation of Environmental Laws (IMPEL) regulatory model to achieve river, lake, groundwater and marine, water quality objectives and standards Use Chinese and EU environmental water standards as minimum targets. Aim towards Water Framework Directive ecological objectives	Review condition of water resources, rivers etc. impacting on city, upstream and downstream, taking risk assessment and catchment based approaches. Set up monitoring programmes of abstractions, discharges and receiving environment. Model options and scenarios and revise/implement permits. Monitor and enforce regulations and permits Drive improvement programmes and ensure treatment plants are in place and operating
6	**Integrated Drainage and Flood Control Planning** For new and redevelopment areas assess options for use of 'sponge city' – Sustainable Urban Drainage System (SUDS) options to complement core water infrastructure	Ensure new development plans incorporate sponge city concepts and water sensitive design. Use best design and operational practice as outlined in this and other reports

		Consider in the context of improved lifestyle and blue-space opportunities Assess and publicise benefits
7	**Stakeholder Participation** Engage the key stakeholders and public in the decision making process Use water framework directive (WFD) engagement principles and build capability to engage.	There is increasing need to engage stakeholders in the water planning process. Engage other Ministries especially Ministry of Water Resources and Ministry of Environmental Protection as they have responsibilities for elements of water planning and delivery Engage key business and property developers Also community leaders and general public Will need to develop knowledge and capability in the city planning department and key stakeholders to achieve this
8	**Strengthen Water Economy** Understand and utilise economic tools and assessments a. Full cost of water service b. Water Tariff structures c. Inward investment and privatisation options d. Assessment of benefits	There is considerable potential to utilise economic instruments and incentives to assist change. They must be used to complement good regulatory practice and to reinforce change. Water should be self-financing and a goal should be to move towards society paying full cost of water service. Water tariff structures can reduce demand and waste. Inward investment may help finance and mechanisms to assist in expensive and core infrastructure provision may be needed. Could consider privatisation and other financing mechanisms (see Finance Section)

		Benefits assessment methods and understanding will assist in developing the business case, but not all can be monetized.
9	**River Basin Management** Environment, ecology, bio-diversity, River Restoration – leisure and recreation space, Tourism Utilise and develop a water framework directive (WFD) capability and long term plan	The environmental protection and improvements to water resources should be considered. Biological and fish monitoring can be used as pubic focus for water resource improvement (eg Salmon in River Thames in London). River restoration and 'soft' engineering will improve habitat potential for citizens and wildlife. Improvements to recreation, in and near water and possible bathing waters. Potential for property enhancement and tourism Develop ecological monitoring and assessment capability
10	**Staff development and capacity building** The issues highlighted will require new capabilities and approaches. Modification of best practice to suit the current Chinese situation will be needed and the EU may be able to assist.	In order to make these improvements new skills and capability will be needed. Training existing staff and recruiting new skills will be important.

Verification methodology. The above parameters and values will be used for verification of the adoption of ecocities´ water performance.

Expected impact. The application of the water management approaches and technologies are expected to achieve a substantially higher, measurable impacts on water sector performance. It will trigger increased investment, reduce energy consumption and CO2 emissions, and augment the number of jobs in the sector.

Responsibilities for Implementation. The responsibility for use and application of this Eco-City Implementation Guideline rests with the city administrations, provincial agencies, and the local MoHURD offices. MoHURD and CSUS will provide technical support and specific guidance where required. In its intention to pursue consistency of eco-city

development, MoHURD is committed to verify the achievement of targets and to ensure improved performance on an annual basis.

Monitoring and review. MoHURD will monitor and review periodically (i.e. annually) the results of the application of this Eco-City Implementation Guideline. For monitoring and periodic review it will utilize indicators as provided above. The city administrations (and district administrations), supported by the local MoHURD offices, will make regular use of these indicators as a means to measure performance.

Date issued: _____ 201_

ANNEX

Annex 1 – Technical Annex

(still to be added, once work in EC-Link cities completed)

Annex 2

MoHURD. 2015. *Appraisal Standards for Green Eco-Districts.* Beijing. (draft).

Excerpt

Resource & Carbon Emission	Controlled Criteria	Develop energy conservation plan, integrated use of various energy.			
		Develop "integrated utilization plan of water resource" during the planning stage, while during the operation stage develop "the report on the status, assessment and development plan of water utilization".			
		Submit detailed and reasonable carbon emission calculation and analysis list, set carbon emission reduction goals stage for stage and the corresponding implementation plan.			
		Water	6. Household water consumption is not higher than the average of upper limit and lower limit in standard GB/T5-331		5
			7. Leakage percentage of water supply pipelines.	leakage percentage is no larger than 8%, or less than the amendatory value in standard CJJ92	3
				leakage percentage is no larger than 7%, or less than 1% the amendatory value in standard CJJ92	4
				leakage percentage is no larger than 8%, or less than 2% lower than the amendatory value in standard CJJ92	5
			8-1. Regenerated water supply system constructed		6
			8-2. Supplying capability of regenerated water, and the corresponding coverage percentage of the supply system	>20%	3
				>30%	4
				>40%	5
				>50%	6
			9. Utilization percentage of non-traditional water resource	>5%	5
				>8%	8